SPECIFICATION

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OPTICAL DISK STAMPER

Background of Invention

[0001] Technical Field

[0002] The present invention relates to stampers applied in the manufacture of optical disks representative of which are DVDs and CDs.

[0003] Description of the Related Art

[0004] Optical disks such as DVDs and CDs are formed with a stamper in a mold made of a metal such as nickel, by pouring molten polycarbonate into the mold, and on the side having the pit-formed surface after molding, forming a vapor-deposition layer and a protective layer to yield an optical disk. By a conventional manufacturing technique of this sort, in parting the post-molded disk from the stamper, articles that mold-releasing irregularities cause to be defective are liable to be produced, with the defective rate amounting to 10-20 percent of the total. Specifically, although the disk is supposed to separate from the mold after it is opened, areas that then release easily from the mold and areas that do not will arise, and in the areas that release reluctantly the bumps furnished on the stamper side of the mold strike the edges on the opening rims of the pits transferred onto the disk, which ends up deforming the pits' contour. This mold-release defect, which spreads mottled-like on the impressed face of the disk, is referred to as clouding due to its nebulous, white-/black-dotted appearancelook; and dsks defective in outwlook nce are not shipped out but are disposed of.

[0005] In connection with this kind of optical-disk manufacturing method, a proposal for improving the releasability of disks from mold stampers has been made known to the public in Japanese Pat. Pub. No. 251. 5. Therein, after the stamper reverse face that contacts the inner surface of the die has been polished to under 0.1 s, by grinding the

just-polished face with a polishing material such as sandpaper to roughen the surface texture to 0.3 to 02 s, the surface area of the stamper with respect to the die is decreased to suppress heat transmission to the. . Nevertheless, roughening the reverse face of the stamper unavoidably leads to the occurrence between the stamper and the die of relative displacement following on differences in thermal expansion and shrinkage rates, which makes the stamper reverse face quickly wear out and shortens its life span.

[0006] As a result of investigating causes giving rise to mold-release defects, the present inventor noted irregularities in the manner in which heat is conducted from the stamper to the die and came upon the scheme for the present inven. n. The temperature of the molten resin poured into the d and the die temperature each differ somewhat during molding according to the molding conditions and the type of disk that is to be molded, but for the most part molten-resin temperatures are generally 300 to 400 ° C; die temperatures 80 to 1. . In this connection, stampers are made with nickel plate as a base material, and nickel's therdiffusivity mal (coefficient of thermal diffusion) per unit time is fairly large (0.085 m^2). Consequently, it is conceivable that simultaneously with the molten resin that is fi ed into the die coming into contact with the molding surface of the stamper, the heat of the molten resin gets absorbed by the die via the stamper, rapidly cooling and hardening the molten-resin surface in contact with the sta. r. As long as this hardening occurs equally over the entire disk including the land surface, and further as long as shrinkage of the resin takes place uniformly until the mold is opened, there will be no room for mold-release defects to arise; but in practice a large volume of defective products are produced, as noted earlier.

[0007] The molten resin that, contacting the stamper, locally is rapidly cooled and hardened as noted above divides into a hardened skin layer and a flowing layer that flows into the central space within the mold cavity; but the facility with which the skin layer traces the external configuration of the bumps deteriorates remarkably once hardening has se. n. Consequently, the configurations of the bumps on the stamper do not get transferred accura. y. In order to avert this sort of transfer defect and furthermore, reduce the flow resistance of the molten resin within the mold cavity, an injection-compression molding technique has been ado. d. Therein, the force with which the mold is clamped in fil ng the molten resin into the cavity is lowered; then

raising the mold-clamping force simultaneously with terminating the molten-resin fill causes the molten resin to adhere to the bumps, improving the transferabi. y. Nevertheless, although the injection- compression molding technique heightens the molten resin transferability insofar as the mold clamping force is increased, the technique does not go so far as to nullify the local rapid cooling and hardening of the molten resin surface; presumably, because local internal stress is produced due to hardening inconsistencies as noted earlier, areas that release easily from the mold and areas that do not are created and the bumps furnished on the stamper side deform the configurations of the pits, which ends up clouding the disk.

Summary of Invention

[0008] An object of the present invention is an optical-disk stamper that nullifies mold-release defects stemming from mold-releasing irregularities when the mold is opened and meanwhile improves transferability during disk molding, to enable manufacturing high-quality optical disks at a favorable yield . e. Another object of the present invention is an optical disk stamper that nullifies rapid cooling and quick hardening of the surface of molten resin that is in contact with the molding face of the stamper to enable resolving mold-release defects originating in incidents of inconsistent internal st. s. A further object of the present invention is an optical-disk stamper whose durability is improved and lifespan prolonged, and that enables favorable-yield-rate manufacturing as in the foregoing, and that at the same time enables manufacturing high-quality optical disks at low cost.

[0009] An optical-disk stamper set forth by the present invention, as shown in Figure 1, is characterized in that on one side of a stamper body *1* a molding surface *2* furnished with bumps *3* for transfer-forming pits onto an optical disk is formed, and in that the molding surface *2*, including bumps *3*, is formed of a polymer resin whose the diffusivity mal is 0.01 m^2/h or less.

[0010] Specifically, the entire stamper body *1* is formed from a polymer resin whose thermal diffusivity is 0.01 m^2/h or less, superficially on which the molding surface *2* furnished with the bumps *3* is formed.

[0011]

Another stamper, as shown in Figure 7, is composed of a stamper body *11*,

formed from a metal baseplate, and a molding layer *12* laminated onto one side of the stamper body . The molding layer *12* is formed from a polymer resin whose thermal diffusivity is 0.01 m^2/h or less, and the exterior face thereof is furnished with bumps *13* to form the molding sur. e.

[0012] Yet another stamper, as shown in Figure 8, is composed of a stamper body *21* , formed from a metal baseplaon te, one side of which is provided a molding surface *22* furnished with bumps *23* , the molding surface *22* , including the bumps *23* being coated with a polymer-resin coating layer *24* whose thermal diffusivity is 0.01 m^2/h or less.

[0013] The polymer resins noted above re made up of heat-hardening resins including phenolic resins and epoxy resins whose thermal diffusivit is between 0.0004 and 0.001 m^2/h.

[0014] From the following detailed description in conjunction with the accompanying drawings, the foregoing and other objects, features, aspects and advantages of the present invention will become readily apparent to those skilled in the art.

Brief Description of Drawings

[0015] Figure 1 is a fragmentary sectional view schematic ly illustrating a stamper embodied according to one aspect of the present invention;

[0016] Figures 2 through 6 are fragmentary sectional views illustrating processes in the course of manufacturing the stamper of Fig. 1, wherein a laser and its beam are represented schematically in Figure 3;

[0017] Figure 7 is a fragmentary sectional view schematically illustrating a stamper embodied according to a separate aspect of the present invention; nd

[0018] Figure 8 is a fragmentary sectional view schematically illustrating a stamper embodied according to a different separate aspect of the present invention.

Detailed Description

[0019] In the present invention, by forming the molding surface *2* provided on one side of the stamper body *1* from a polymer resin that is a poor heat conductor whose

thermal diffusivity is less than 0.01 m^2/h, during the disk-molding process local hardening of the molten-resin surface by the heat of the molten resin that contacts the molding surface *2* being rapidly absorbed by the molding die through the molding surface *2* and the stamper body *1* is nullified. This prevents the surface of the molten resin filled into the ie from hardening locally and enables gradually hardening of the disk as a whole. Accordingly, the fact that the resin filled into the mold may be maintained in a sufficiently soft state when the mold is clamped shut at the same time the molten-resin filling is ended causes the molten resin to adhere to the bumps *3* without gaps, enabling accurate transfer of the bump *3* configurations. Furthermore, the amount of time required to clamp the mold can be short ed compared to that of disk-forming processes using conventional stampers, therefore shortening the amount of time required for the disk-forming cycle, ultimately impro ng productivity. The amount of pressure applied for mold-clamping can also be reduced.

[0020] Insofar as the hardening of the post-filled resin is gradual, the hardening of the disk as a whole will be made the more uniform and the occurrence of internal stress due to local irregularities from rapid hardening will be the more certainly prevented--and the resin shrinkage that accompanies hardening will also be made the more uniform. Therefore, the clouding du ng mold-release that has been unavoidable with conventional stampers may be eliminated, remarkably lessening the occurrence of defective products and improving productivity in the manufacture of optical disks. Accordingly, the present invention enables the manufacture of high quality optical disks at a high yield-rate. It should be understood that if the thermal diffusivity of the polymer resin that the molding surface *2* is made of exceeds 0.01 m^2/h, the speed and amount of heat conduction grow, which makes the resin that contacts the molding surface *2* cool and harden more rap. y.

[0021] Forming the entire stamper body *1* out of a polymer r in whose thermal diffusivity is less than 0.01 m^2/h, and forming on the surface of the stamper the molding-surface *2* furnished with the bumps *3* , significantly reduces the amount of conducted heat that passes through the stamper body *1* per unit time compared, for example, to a stamper made of nickel only, to reliably prevent abrupt cooling of the molten-resin filled into the mold. In comparison with the high-cost of the nickel used to form conventi al stampers, this invention also lowers the manufacturing costs of the

stamper itself.

[0022] With a stamper wherein the molding layer *12* is built on a metal-baseplate formed stamper body *11* by laminating on one of its lateral faces a polymer resin whose thermal diffusivity is less than 0.01 m^2/h, and the obverse surface thereof is formed as the molding surface including bumps *13*, despite the stamper body *11* expanding and contracting attendant on the heat-cycling changes of the molding machine and friction arising where the stamper and the mold come into contact, the stamper body *11* will ultimately be kept from wearing out, improving its durability and prolonging its lifespan. In particular, this stamper exhibits the same level of durability as that of conventional stampers made entirely of nickel. With a molding layer *12* being formed on the surface of a metal stamper body *11*, the molding layer *12* will sufficiently demonstrate a heat-conduction deterrent effect, yielding a stamper superior in overall characteristics.

[0023] A stamper wherein a molding surface *22* including bumps *23* is formed on one of the lateral faces of a metal-baseplate formed stamper body *21* and a coating layer *24* is built superficially on the molding surface *22* including the bumps *23* by coating on a polymer resin exhibits a heat-conduction deterrent effect due to the coating layer *24* while demonstrating the same mechanical strength as the stamper body of an all-metal stamper, and therefore, compared with conventional stampers made only of nickel, prevents incidents of clouding during mold-rel se to reduce occurrences of defective products.

[0024] General phenolic resins and epoxy resins have coefficiets of thermal diffusion between 0.0004 and 0.001 m^2/h, and have been experimentally confirmed to improve mold-release characteristics. The cooling time required for resins with a thermal diffusivity less than 0.0004 m^2/h is too long, which lowers productivity. Although coefficients of thermal diffusion in the range of 0.001 to 0.01 m^2/h improve mold-release characteristics over the status quo, coefficients under 0.001 m^2/h are preferable when considering overall characteristics including transferability.

[0025] Reference is made to Figures 1 and 2, which illustrate one embodiment of an optical-disk stamper having to do with the present invention. The stamper consists of the stamper body *1* and the molding surface *2* that is formed one side of the stamper

body *1* ; the entire stamper body *1* is made of a polymer heat-hardening resin. A set of bumps *3* is formed on the molding surface *2* for transfer-forming pits o an optical disk. The most suitable polymer heat-hardening resins for making the stamper body *1* are phenolic resins and epoxy resins, particularly reswhose thermal diffusivity is ion less than 0.01 m^2/h, and more preferably phenol-resin mono whose h a thermal diffusivis ity 0.0004 to 0.001 m^2/h; polymer resins containing phenolic resins are otherwise suitable.

[0026] In this manner, the stamper body *1* made out of a polymer resin whose thermal diffusivity is small (that is a poor heat conductor) prevents the heat of the molten resin, such as polycarbonate, that contacts the molding surface *2* during the molding process from being rapidly absorbed by the mold via the molding surface *2* and the stamper body *1* . Because the thermal gradient between the molten resin and the stamper body *1* may be sustained large over a long period, the molten resin takes its time hardening. This as a result imparts sufficient softness to the molten resin wherein the mold-clamping pressure is increased at the same time fill-introduction of the molten resin is terminated, consequently allowing the molten resin to adhere without gaps to the bumps *3* and enabling high-fidelity transfer of the bump configurations. Furthermore, the amount of time required for clamping the mold in this cas is shorter than that for conventional molds, reducing the disk-forming cycle period and therefore improving productivity. The amount of pressure applied during mold-clamping may also be reduced. Insofar as the disk hardens leisurely, the disk as a whole will harden more consistently, which therefore more assuredly prevents the occurrence of internal stress attendant on local irregularities from rapid hardening. As the hardening of the disk proceeds the more consistently in this way, the shrinking of the resin attendant on hardening is made unifoand rm, the disks obtained may be readily released from the mold, without any clouding when released.

[0027] In fact, with conventional stampers formed from nickel, because the thermal diffusivitythe of nickel used is 0.085 m^2/h--an exponentially large coefficient compared with the 0.001 m^2/h thermal diffusivity of phenolic resins--the heat of the polycarbonate ends up being rapidly absorbed by the molding die via the molding surface and the stamper, so that the thermal gradient between the molten resin and the stamper inevitably becomes abruptly smaller. As a result, the resin surface that

contacts the molding surface hardens rapidly, not only forfeiting any improvements in the transferability that should come from clamping the mold, but unavoidably creating internal stresses that are attendant on local irregularities from rapid hardening.

[0028] The manufacturing process for the stamper described above is illustrated in Figures 2 through 6.

[0029] *Exposure Layer Formation Process* : First, as shown in Figure 2 an exposure layer *6* is formed by applying a negative photoresist on one side of a phenol-resin base *5* that has been adjusted to a specific thickness, and then drying it hard.

[0030] *Photolithography Process* : Next, as shown in Figure 3, the base *5* is rotated a prescribed number of revolutions, and a laser head *7* is moved radially along the base *5* while a laser beam *8*, which is modul ed according to prerecorded informational signals, intermittently irradiates the exposure layer *6* to record a spiral latent image thereon.

[0031] *Developing Process* : As shown in Figure 4, bump prototypes *9* are formed by immersing the exposed base *5* in a developing solution that develops the recorded image, and then dissolving and removing the photo-resist remaining on the unexposed areas.

[0032] *Etching Process* : As shown in Figure 5, etched depressions *10* are then formed by masking the bump prototypes *9* and dry-etching the exposed surface of the base *5*.

[0033] *Photo-resist Removal Process* : Finally, as shown in Figure 6, a base *5* formed with bumps *3* in the traces of the removed bump prototypes *9*--in other w, a the stamper *1* --is obtained by removing the bump prototypes *9* remaining after etching. An ashing technique of exposing the bump prototypes *9* to oxygen plasma to turn them to ash, or dissolving off the bump prototypes *9* using a sol,vent are ways to remove the bump prototypes *9*.

[0034]

Reference is now made to Figure 3, which illustrates another embodiment of a stamper having to do with the pre nt invention. In this embodiment, the stamper is composed of the stamper body *1 1*, which is formed from a metal baseplate, and the molding layer *12*, which is laminated to one side of the stamper body *1 1*. The

stamper body *1 1* is made from a nickel plate material superficially onto which a molten phenolic resin is applied and dried-hardened, forming a 0.1 to 10 μm thick molding layer *12* when dry. The same raw material used for the base *5* described in the foregoing embodiment may also be utilized for the phenolic resin when making the molding layer *12* . After the molding layer *12* is built, the bumps *13* are formed o it superficially by the same procedure as described in the previous embodiment. Materials other than nickel, such as aluminum and stainless steel plates, can also be adopted as the formative raw material for the stamper body *1 1* . If the dry thickness of the molding layer *12* is less than 0.1 μm, securing the necessary height for the bumps becomes difficult; if the thickness exceeds 10 μm, the adherence of the molding layer *12* to the metal baseplate grows poor. The most preferable thickness should be 1 to 2 μm.

[0035] Making the stamper body *1 1* out of a nickel or other metal baseplate in this manner enhances the mechanical lifespan of the stamper and enables using the stamper over an extended period of time. To be more specific, when mol ng optical disks, the stamper thermally expands, or else contracts, following changes in the heat cycle of the molding machine, and extending and shrinking of the stamper body *1 1* leads to friction occurring where the stamper is contact with the mold, wearing it out before long. Nevertheless, because forming the stamper body *1 1* from a nickel or other metal baseplate ultimately keeps it from wearing out due to friction, the stamper body *1 1* exhibits the same durability as that of conventional stampers that are made entirely of nickel.

[0036] Referring now to Figure 4, which shows yet another embodiment of a stamper having to do with the present invention, in this embodiment, the molding surface *2 2* furnished with bumps *23* is provided on one surface of a stamper body *21* , which is made of a nickel plate material; and the molding surface *2 2* including the bumps *23* is coated with a phenolic resin film whose thermal diffusivity is--likewise as in the foregoing embodiments--less than $0.001 m^2/h$. Reference mark *24* in the figure indicates this coating layer. The technique illustrated in Figures 2 through 6 can as such be adopted as a method for forming on the stamper b *21* y 21the molding surface *2 2* furnished with the bumps *23* . Spread-coating or vapor deposition may be employed as coating methods for forming the coating layer *24* , but using a spinning

method to coat the surface is the most cost effective method and produces a high-grade film of uniform thickness. The dry thickness of the coating layer *24* should be in the range of a few hundred to a few thousand Å . The stamper in this embodiment, likewise as in the foregoing embodiments, lets the stamper body *21* be saved from wear originating in the extending and shrinking attendant on changes in the molding-machine heat cycle, improving the stamper's durability with long-term use.

[0037] By laminating the signal-recording surface of disks obtained using the above-described stamper(s) with a reflective layer and a protective layer, DVDs, CDs, or MDs can be manufactured and, by bonding two disks back-to-back, double-sided DVDs can also be manufactured.

[0038] Only selected embodiments have been chosen to illustrate the present inven. n. To those skilled in the art, however, it will be apparent from the foregoing disclosure that various changes and modifications can be made herein without departing from the scope of the invention as defined in the appended cl. s. Furthermore, the foregoing description of the embodiments according to the present invention is provided for illustration only, and not for limiting the invention as defined by the appended claims and their equivalents.